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著者	Satoh I., Tomiyama H., Mitsugashira T., Nomura A., Suzuki S.
journal or publication title	CYRIC annual report
volume	1984
page range	55-57
year	1984
URL	http://hdl.handle.net/10097/49217

I. 13 A Production of the Promethium Tracers

Satoh I., Tomiyama H., Mitsugashira T., Nomura A. and Suzuki S.
The Research Institute for Iron, Steel and Other Metals, Tohoku University

^{147}Pm, one of the main fission products, has been commonly used as a radioactive tracer for Pm. It emits almost no γ-rays and is not so convenient to apply to tracer experiments. Therefore, it is desirable to search for γ-emitters in Pm isotopes which will be produced easily and more suitable for tracers than ^{147}Pm. The two γ-emitters $^{144}Pm(t_{1/2}=1y)$ and $^{143}Pm(t_{1/2}=265d)$ are promising candidates and they can be produced by α-particle bombardment on ^{141}Pr, which is the only naturally occurring isotope of Pr. No radioisotopes of Nd and Pr are produced by $^{141}Pr+\alpha$ reaction when the energy of α-particle is below 40 MeV. And the difference in the atomic number of Pr and Pm is 2. Thus, the chemical procedure for the isolation of the products ^{143}Pm and ^{144}Pm from the target Pr will be simpler than that of the other production method of Nd+p or Nd+d reaction.

Materials and Method

The irradiation box is shown in Fig. 1. The main parts of the box are made of aluminum except part 1 which is made of stainless steel. Part 2 is a gate valve and part 3 is a beam monitor which contains an alumina monitor plate to see the beam profile. Part 4 is a slit and part 5 includes a target holder, which is shown in Fig. 2. The parts 4 and 5 are insulated electrically by the teflon insulator, and the beam current of each part can be accumulated separately. The parts 4 and 5 are cooled by water.

The experiment was carried out twice. First, a thick target of 22 mmφ Pr metal (0.814 g/cm^2) was bombarded by 40 MeV α-particles. The mean beam current was 1.24 μA, and the irradiation time was 11 hours. In the second experiment, the excitation function for the reaction of $^{141}Pr(\alpha,2n)^{143}Pm$ was measured up to 40 MeV by means of the stacked foil method. The target system was shown in Fig. 2. The target holder included five Pr foil targets which were prepared by vacuum sublimation on Ni foils (25.5 mmφ). The thickness of each ^{141}Pr target was 365 $\mu g/cm^2$ and Ni foil was 19.3 mg/cm^2. At the back of the each Ni foil, an Al foil (6.98 mg/cm^2) was placed as a catcher foil to see the recoil yield of ^{143}Pm and ^{144}Pm. The mean current of 40 MeV α-beam was 77.8 nA, and the irradiation time was 12 hours. A few days after the irradiation, the activities of the ^{143}Pm and the ^{144}Pm were quantified by γ-ray spectrometry.

Results and Discussion

In the first experiment, 60 μCi of ^{143}Pm and 5.6 μCi of ^{144}Pm were produced. The thick target yields were measured to be 4.4 μCi/μA·h for ^{143}Pm and 0.41 μCi/μA·h for ^{144}Pm. These corresponded to 4.0×10^{4} μCi/μA for ^{143}Pm and 5.2×10^{3} μCi/μA for ^{144}Pm at the infinite irradiation time. The value of ^{143}Pm was in good agreement with the estimated value given in Ref. 1. But for ^{144}Pm the measured value was about 1.5 times larger than that shown in the same reference.

The excitation function of $^{141}Pr(\alpha,2n)^{143}Pm$ reaction determined by the second experiment was shown in Fig. 3. No characteristic peaks of ^{144}Pm could be observed in the γ-ray spectra of the targets and the catcher foils that were obtained by 40000 sec accumulation. In general, the maximum cross section of the (α,n) reaction of the lanthanoid element is about one order of magnitude lower than that of the (α,2n) reaction. The profile of the excitation function was also in good agreement with that shown in Ref. 1.

Reference

1) Landolt-Börnstein: Numerical data and functional relationships in science and technology, New Series, Group I, Vol. 5 (Springer, DEU).

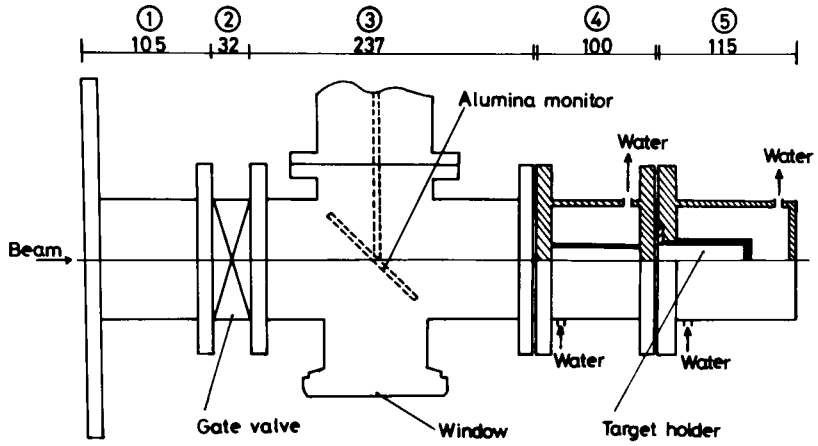

Fig. 1. Irradiation box.

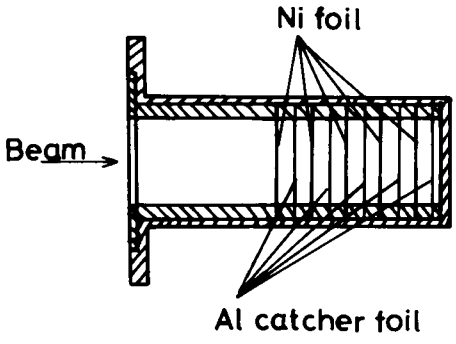

Fig. 2. Target holder.

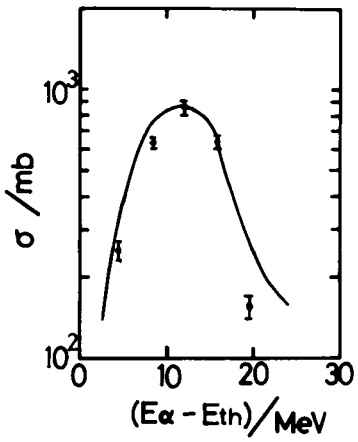

Fig. 3. Excitation function of $^{141}Pr(\alpha,2n)^{143}Pm$ reaction. Solid curve: Reference 1, E_{th}: Threshold energy 17.3 MeV.